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(19)

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(54) IMPROVEMENTS IN OR RELATING TO COMMUNICATION SYSTEMS

(71) We, THE PLESSEY COMPANY LIMITED, a British Company of 2/60 Vicarage Lane, Ilford, Essex, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention relates to communication systems and relates more especially to a receiving arrangement for use in such systems.

In signal intercept and monitoring systems, or in mobile communication systems the initial arrival of a signal may be from an unknown direction. For signal acquisition it is important to have "listening out" with wide angular coverage to avoid missing signals, and hence typically to have an omnidirectional aerial pattern. Once a signal is detected a good signal to noise ratio is required for listening and aerial directivity or gain is a means of obtaining improvement. Typically a set of fixed beams would be provided for the operator to make a choice by switching between beams to determine which is best for reception of the particular signal, or alternatively a directional aerial would be provided which is steered or scanned by mechanical movement to the direction of signal arrival. This process is slow and non-optimum and is also an additional task load on the operator.

The present invention relates to a receiving arrangement which enables near optimum performance to be obtained rapidly and automatically, thus reducing the load on the operator.

According to the present invention there is provided a receiving arrangement comprising a plurality of receiving aerials; means for relatively phasing output signals derived from the aerials to provide a first relatively broad receiving pattern and means operable on a signal received by the arrangement for adjusting the relative phasing between the aerials to change the receiving pattern from the first relativelyh broad receiving pattern to a second relatively narrow receiving pattern pointed in the general direction of the said signal.

In carrying out the invention it may be arranged that the receiving arrangement comprises phase changing means associated with each of the receiving aerials and to which the output of the associated aerial is applied, combining means for combining the outputs from said phase changing means and signal receiver means to which the combined outputs is applied, means being provided, operable when a signal is received by said arrangement, for causing the phase change afforded by each of the phase changing means to be changed in order to obtain an increased output from the signal receiver means.

In such an arrangement it may be arranged that the control means is effective for causing each of the phase changing means to be selected and for causing the phase change afforded by a selected phase changing means to be changed so as to cause an increase in output from the signal receiver means to be obtained.

In one arrangement the phase change afforded by the selected phase changing means may be successively changed in steps and preferably the phase change afforded by the selected phase changing means is cyclically varied between two step values, sense signal demodulator means being provided, the output from which is preferably afforded via integrator means, operable on the output of the signal receiver means for detecting an increase or decrease in signal receiver means output.

Advantageously the sense signal demodulator may be arranged to operate synchronously with the cyclic variation of the selected phase changing means.

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In an especially envisaged arrangement in accordance with the invention, store means will be provided associated with each of the phase changing means for storing information relating to the phase change to which that phase changing means is setting and progressive control means will be provided for incrementing the store means association with a selected phase changing dependent upon the output of the sense signal demodulator means.

In such an arrangement the store means associated with a selected phase changing means may be incremented consequent upon the simultaneous occurrence of an output from the progressive control means and an output from switching generator means which controls the cyclic variation of the phase changing means, the store means being incremented by one each time the output from thesense signal demodulator indicates an increase from the signal receiver means.

In another preferred arrangement in accordance with the invention it may be arranged that the control means is effective for causing two or more of the phase changing means to be selected, in which case the arrangement may comprise switching generator means for controlling the cyclic switching of selected phase changing means and for affording phase displaced outputs to a plurality of sense signal demodulator means, integrator means being provided operable individually on the outputs of the sense signal demodulator means and resettable under the control of the switching generator means, means being provided operable on the output of each of the integrator means for detecting an increase in amplitude from the signal receiver means and for causing phase change afforded by the selected phase changing means to be cyclically changed in steps to produce an increase in output from the signal receiver means.

Some exemplary embodiments of the invention will now be described, reference being made to the drawings accompanying the provisional specification, in which:

Figures 1 and 2 are block schematic diagrams depicting different ways of combining the outputs of a plurality of receiving aerials that form part of a receiving arrangement according to the present invention;

Figure 3 is a block schematic diagram of a receiving arrangement according to the present invention, and

Figure 4 is a modification of the receiving arrangement of Figure 3 that enables a plurality of the receiving aerials to be selected for phase variation purposes.

The function of the receiving arrangement of the present invention is to provide a substantially uniform omnidirectional receiving pattern or if required a broad beam coverage in a required direction for "listening-out" purposes and when a signal has been received to change the directivity pattern to make it very directive in the direction of the received signal thereby to obtain an improved signal-to-noise ratio.

It is known in some conventional receiving arrangements to provide an array of omnidirectional or broad-beam aerials, the outputs of which are adjuseted in phase and combined in order to obtain a required directivity pattern. In Figures 1 and 2 there are shown two ways of achieving this.

In Figure 1, a plurality of aerials 1 are provided, the number in the embodiment shown being eight, the outputs from seven of which are applied to respective electrical phase shifters 2 which enable the phase of the signals afforded thereby to be varied relative to the eighth aerial. The eight outputs thus afforded are successively combined in pairs using 3dB Hybrid couplers 3 to afford a combined output 4.

In the arrangement shown in Figure 2 of the drawings, instead of the phased outputs afforded by the aerials 1 being combined using 3dB hybrid couplers as in the arrangement of Figure 1 they are successively combined using directional couplers 5 to afford the combined output 4.

Typically in the arrangements of Figures 1 and 2, the aerials 1 may each have an omnidirectional receiving pattern and be arranged on the periphery of a circle, the phase shifters 2 being arranged so that the aerials 1 are phased by successively increasing steps of $\frac{\pi}{4}$ radians from one to the next thereby to afford to the array an omnidirectional receiving pattern.

The phases of the phase shifters 2 in the arrangements are determined by means of control signals 6 applied thereto and the required settings for these to enable an omnidirectional receiging pattern or one or more broad beam patterns to be obtained may be stored in a suitable store e.g. wire patch, semiconductor, magnetic or punched card so that broad coverage may be obtained by means of a simple instruction by the operator (e.g. push button). The operator maintains this broad coverage condition until a signal is received at which time it is required to change the receiving pattern of the arrangement so that it becomes highly directive in the direction of the received signal. A simplified arrangement for effecting- this is shown in Figures 3 of the accompanying drawings.

In the arrangement shown in Figure 3, a plurality of aerials 1 are provided the output of each of which is applied to a respective electrical phase shifter 2, the phase shift of which is determined in accordance with a control signal 6 applied thereto. Although

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not shown in Figure 3, the outputs from the phase shifter 2 are suitably combined in a manner, for example, as described with reference to the arrangements of Figure 1 or Figure 2, and the combined output 4 is applied to a receiver 7. Initially, the control signals 6 applied to the phase shifters 2 are chosen so as to provide the required omni-directional or broad beam coverage required for "listening-out" purposes. On receipt of a signal it is arranged that the control loop 8 as depicted in Figure 3 is brought into action. This has the effect of causing each of the phase shifters 2 to be selected in turn and arranges that the selected phase shift is switches between two phase values (typically different by say $\frac{\pi}{4}$ radians) and the resultant regular change of signal level from the receiver 7 is used to determine whether the phase of the selected phase shifter 2 should be increased or not. If it is determined that the phase should be increased, the phase of the selected phase shifter 2 is increased by one increment and the process is repeated. In this way the phase of the selected phase shifter 2 is progressively increased until a decrease in phase shift is determined at which time the selected phase shifter 2 is set back one increment and the next phase shifter 2 selected for the process to be repeated.

Turning now to the arrangement depicted in Figure 3, a sense switching generator 9 is provided which affords a square wave output signal to an 'ADD' circuit 10 and thence to a store 11 which is associated with a particular one Øn of the phase shifters 2. The effect of the signal applied to the store 11 is to cause the phase of the selected phase shifter Øn to be cyclically switched between two values. This regular change in phase causes a regular change in signal level from the receiver 7 which is arranged to afford a sense modulated output signal to a sense signal demodulator 12 to which is also applied an output from the sense switching generator 9. The demodulated output from the sense signal demodulator 12 is applied to a progressive control circuit 13 which determines whether the phase of the selected phase shifter Øn needs to be increased, and if so affords an output to the 'ADD' circuit 10 to cause the store 11 to be stepped on one increment. The process is then repeated until a further increase in phase causes a decrease in the output signal from the receiver 7 at which time the store Øn is stepped back one increment and the output from the 'ADD' circuit 10 is applied to the store 11 (not shown) associated with the next phase shifter 2 to be selected.

The system is arranged to cycle through control of each of the phase shifters 2 in turn and in a static situation one or two cycles may be adequate for achieving a sufficiently close approach to an optimum. In a dynamic situation or where propagation may vary then the system can be left to cycle continuously tracking the signal arrival direction.

As an alternative to cyclically varying the phase of each of the phase shifters 2, it may be arranged that their phases are progressively changed and the resulting change in received signal monitored and used for feedback control. However, this method has the disadvantage of being susceptible to fading effects.

Although at first sight the use of cyclic switching would appear to increase the response time relative to that for the direct use of the progressive change, this is not necessarily so. Integration of the sense signal afforded by the receiver 7 over a period of time is necessary to reduce effects of noise and the integration time need be no longer in the cyclic case. Also because the sense signal is alternating and the demodulation is synchronous more than one phase shifter can be controlled simultaneously by appropriate choice of switching rates and times. For any particular switching rate two of the phase shifters 2 can be controlled by arranging the cyclic switching and sensing for one to be in quadrature with that for the other. A further pair of phase shifters may be controlled by use of a different switching rate which may be synchronised to the first, or may be non-commensurate. If synchronous rates are used then the integration period can also be locked to the switching rate with advantage. For non-commensurate rates then the integration period must be chosen to reduce the effects of random phasing.

Further pairs of phase shifters may be controlled simultaneously if system complexity is acceptable. A further consideration in deciding the maximum number of phase shifters to be controlled at any time is the phase/amplitude fluctuation which it is acceptable to impose on the signal, since in general for a given phase increment the magnitude of the fluctuations will be greater the greater the number of elements controlled simultaneously.

An arrangement for controlling simultaneously a pair of phase shifters is depicted in Figure 4 of the accompanying drawings. In this arrangement a switching generator 14 is provided which affords two output square wave signals 15 and 16 which are in phase quadrature to each other and which are appalied to respective sense signal demodulators 17 and 18 which are both fed with the sense signal output from the receiver 7. The demodulated outputs from each of the sense signal demodulators 17 and 18 are applied to respective integrators 19 and 20 which cause them to be integrated for a

predetermined period determined by a reset circuit 21 operating in conjunction with the switching generator 14. The outputs from the integrators 19 and 20 are fed to respective decision circuits 22 and 23 which compares the signal of the integrated output with that from the previous integration. If the sign of the output is unchanged an output is afforded to an 'ADD' circuit 24 in the case of decision circuit 22 and an 'ADD' circuit 25 in the case of decision circuit 23, the 'ADD' circuit 24 being fed with the output 15 from the switching generator 14 to effect the required cyclic switching and the 'ADD' circuit 25 being fed with the output 16 from the switching generator 14 again to effect the required cyclic switching. The outputs from the 'ADD' circuirs 24 and 25 are applied to respective selector switches 26 and 27 by means of which they may be applied to selected ones of the stores 28 associated with the phase shifters 2. Control of the selector switches 26 and 27 is effected by means of a switch control circuit 29 in dependence upon the outputs from the decision circuits 22 and 23 and is arranged such that the same store 28 is not selected simultaneously by the selector switches 26 and 27 and also arranges that as soon as the phase of a selected phase shifter 2 has been adjusted, selection of a different one of the phase shifters 2 is effected.

A particularly advantage of the systems described is that one receiver is adequate for controlling the beam forming. If a particular signal is being sought as for instance in mobile communications then an identification coding may be added to the signal. At the receiver the coded parts of the signal is separated and used in the control loop.

In addition if it is required to respond to the received signal a transmit-receive switch 30 may be provided which enables the combined output from the aerials 1, after they have been phase adjusted, to be switched from the receiver 7 to a transmitter (not shown).

WHAT WE CLAIM IS:-

1. A receiving arrangement comprising a plurality of receiving aerials; means for relatively phasing output signals derived from the aerials to provide a first relatively broad receiving pattern and means operable on a signal received by the arrangement for adjusting the relative phasing between the aerials to change the receiving pattern from the first relatively broad receiving the pattern to a second relatively narrow receiving pattern pointed in the general direction of the said signal.

2. A receiving arrangement as claimed in claim 1, in which each of the receiving aerials has an omnidirectional receiving pattern.

3. A receiving arrangement as claimed in claim 1 or claim 2, in which the plurality of receiving aerials are disposed relative to one another so as to afford to said arrangement a required overall receiving pattern.

4. A receiving arrangement as claimed in any preceding claim, comprising phase changing means associated with each of the receiving aerials and to which the output of the associated aerial is applied, combining means for combining the outputs from said phase changing means and signal receiver means to which the combined outputs is applied, control means being provided, operable when a signal is received by said arrangement, for causing the phase change afforded by each of the phase changing means to be changed in order to obtain an increased output from the signal receiver means.

5. A receiving arrangement as claimed in claim 4, in which the control means is effective for causing each of the phase changing means to be selected and for causing the phase change afforded by a selected phase changing means to be changed so as to cause an increase in output from the signal receiver means to be obtained.

6. A receiving arrangement as claimed in claim 4, in which the phase change afforded by the selected phase changing means is successively changed in steps.

7. A receiving arrangement as claimed in claim 6, in which the phase change afforded by the selected phase changing means is cyclically varied between two step values, sense signal demodulator means being provided operable on the output of the signal receiver means for detecting an increase of decrease in signal receiver means output.

8. A receiving arrangement as claimed in claim 7, in which the sense signal demodulator operates synchronously with the cyclic variation of the selected phase changing means.

9. A receiving arrangement as claimed in claim 8, in which the output of the sense signal demodulator is afforded via integrator means.

10. A receiving arrangement as claimed in claim 8 or claim 9, comprising store means associated with each of the phase changing means for storing information relating to the phase change to which that phase changing means is setting and progressive contrl means for incrementing the store means associated with a selected phase changing dependent upon the output of the sense signal demodulator means.

11. A receiving arrangement as claimed in claim 10, in which the store means associated with a selected phase changing means is incremented consequent upon the simultaneous occurrence of an output from

the progressive control means and an output from switching generator means which controls the cyclic variation of the phase changing means, the store means being incremented by one each time the output from the sense signal demodulator indicates an increase from the signal receiver means.

12. A receiving arrangement as claimed in any of claims 5 to 11 in which the control means is effective for causing two or more of the phase changing means to be selected.

13. A receiving arrangement as claimed in claim 12, comprising switching generator means for controlling the cyclic switching of selected phase changing means and for affording phase displaced outputs to a plurality of sense signal demodulator means, integrator means being provided operable individually on the outputs of the sense signal demodulator means and resettable under the control of the switching generator means, means being provided operable on the output of each of the integrator means for detecting an increase in amplitude from the signal receiver means and for causing phase change afforded by the selected phase changing means to be cyclically changed in steps to produce an increase in output from the signal receiver means.

14. A receiving arrangement substantially as hereinbefore described with reference to the drawings accompanying the provision specification.

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For the Applicants.

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1577939 PROVISIONAL SPECIFICATION

3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 1

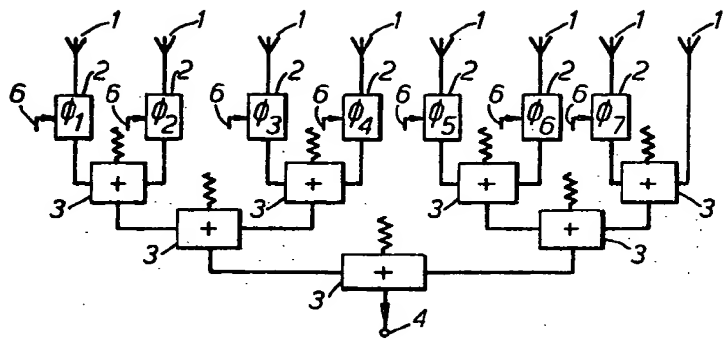

Fig. 1.

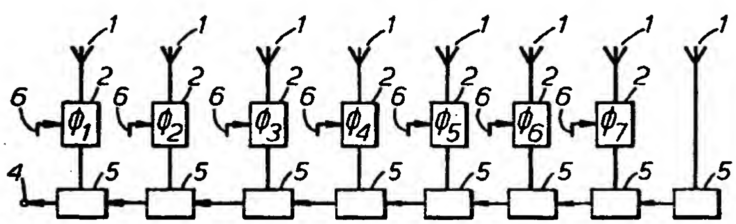

Fig. 2.

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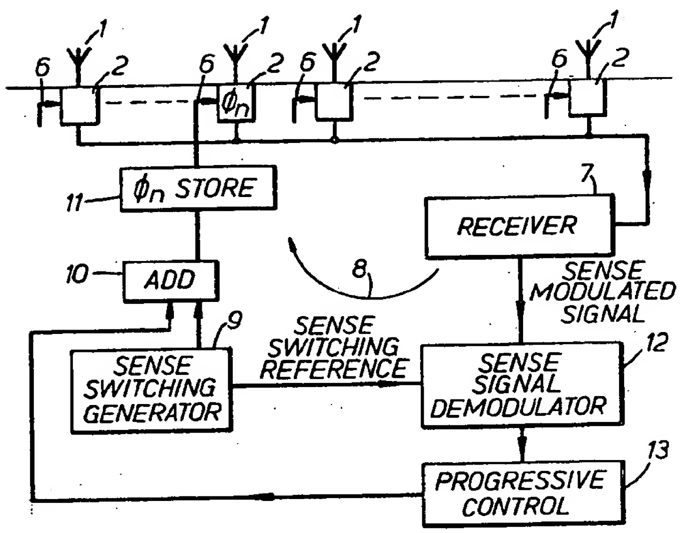
1
2
6
ϕn
7
RECEIVER
8
11
ϕn STORE
10
ADD
9
SENSE SWITCHING GENERATOR
SENSE SWITCHING REFERENCE
SENSE MODULATED SIGNAL
12
SENSE SIGNAL DEMODULATOR
13
PROGRESSIVE CONTROL

FIG. 3.

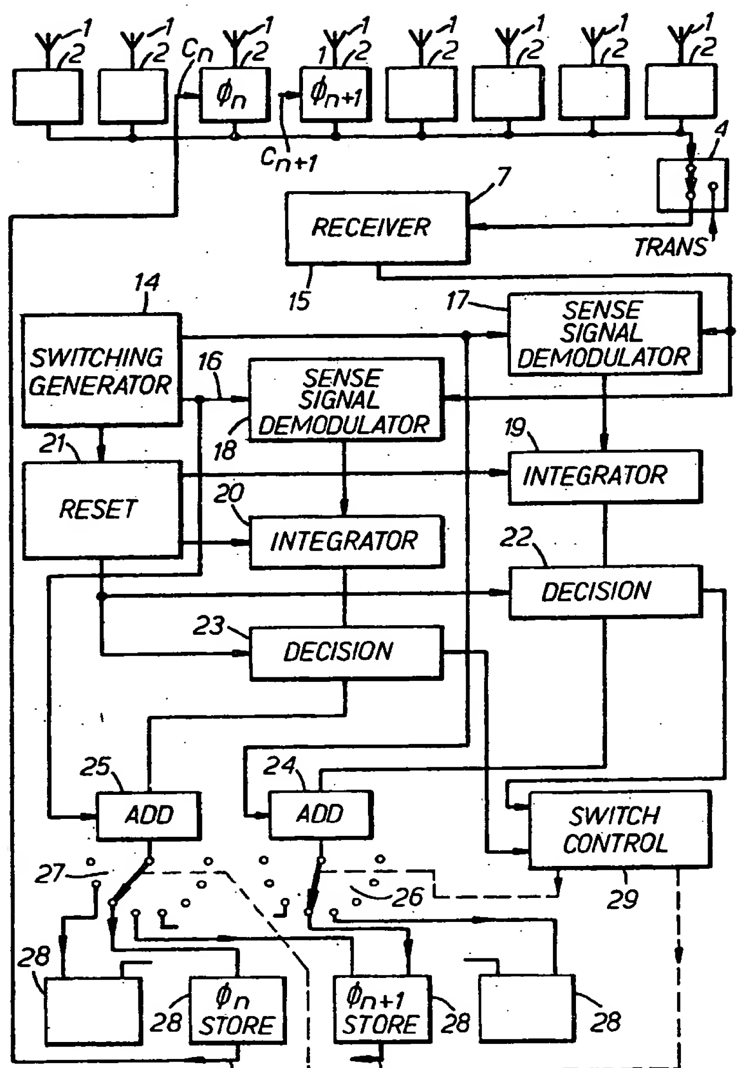
1
2
Cn
φn
φn+1
Cn+1
4
7
RECEIVER
TRANS
14
15
17
SWITCHING GENERATOR
16
SENSE SIGNAL DEMODULATOR
SENSE SIGNAL DEMODULATOR
18
19
21
RESET
INTEGRATOR
20
INTEGRATOR
22
DECISION
23
DECISION
25
24
ADD
ADD
SWITCH CONTROL
27
26
29
28
φn STORE
φn+1 STORE
Cn
Cn+1

FIG. 4.